Information Technology and the UK Research Base

Dr Adrian Mears
Technical Director, QinetiQ
RUSI Conference on Harnessing Advanced Technology for C4ISTAR, 27 September 2001

QinetiQ

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
27SEP2001	N/A	25SEP2001 - 27SEP2001

Title and Subtitle Information Technology and the UK Research Base	**Contract Number**
	Grant Number
	Program Element Number
Author(s) Mears, Adrian	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) QinetiQ	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) EOARD PSC 802 BOX 14 FPO 09499-0014	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)

Distribution/Availability Statement
Approved for public release, distribution unlimited

Supplementary Notes
See Also ADM001419 for whole conference on CD-ROM. These papers are from the Harnessing Advanced Technology for C4ISTAR, The Second Annual Advanced Technology Conference, held 25-27 September 2001 at The Great Malvern Theatre Complex., The original document contains color images.

Abstract

Subject Terms

Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU

Number of Pages
57

Information Technology and the UK Research Base

How strong is the UK’s research base in IT?

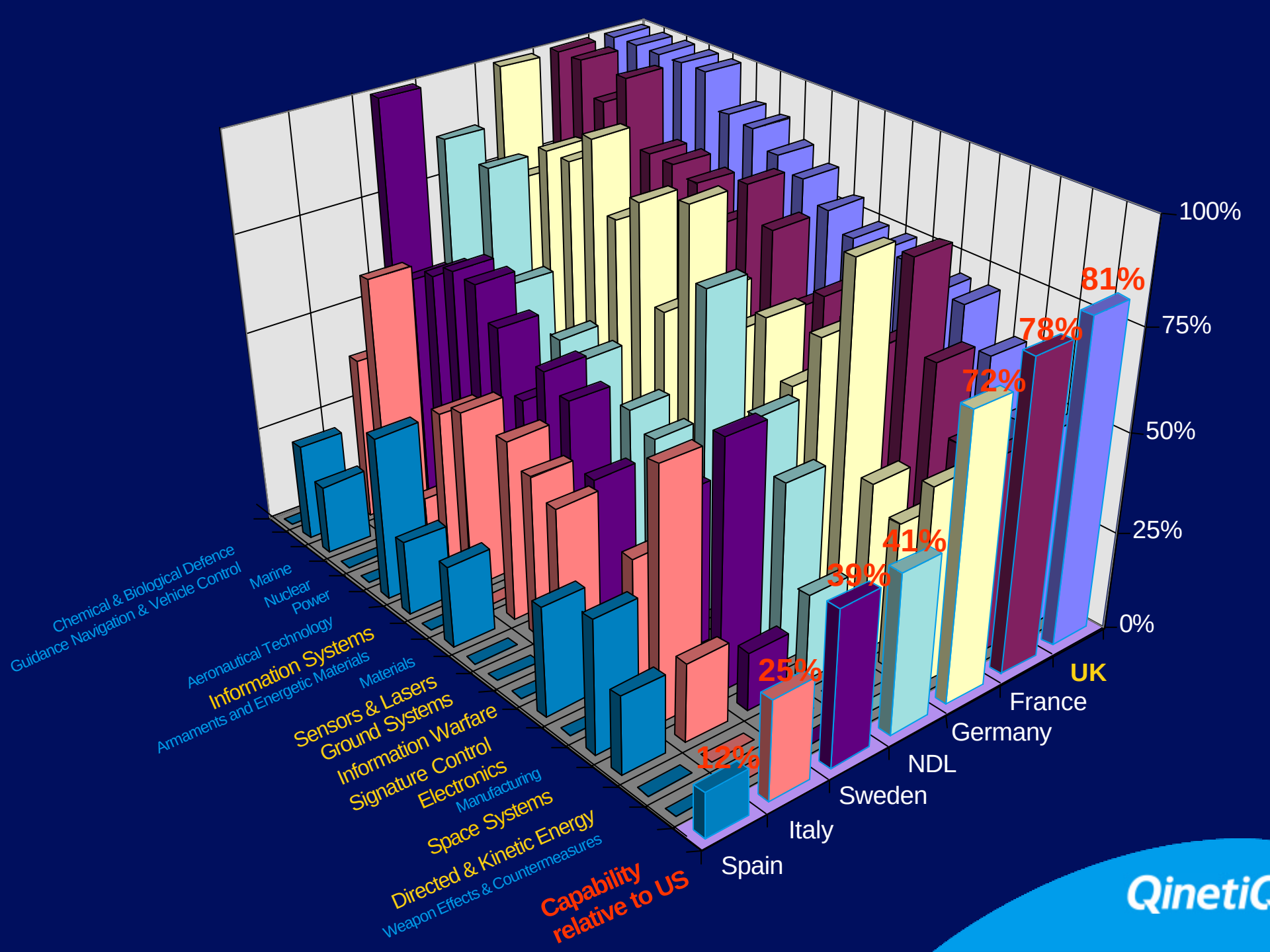
How is IT evolving and what does this mean for defence?

What are the future challenges for C4ISTAR and does this mean for research?

QinetiQ

Section 1

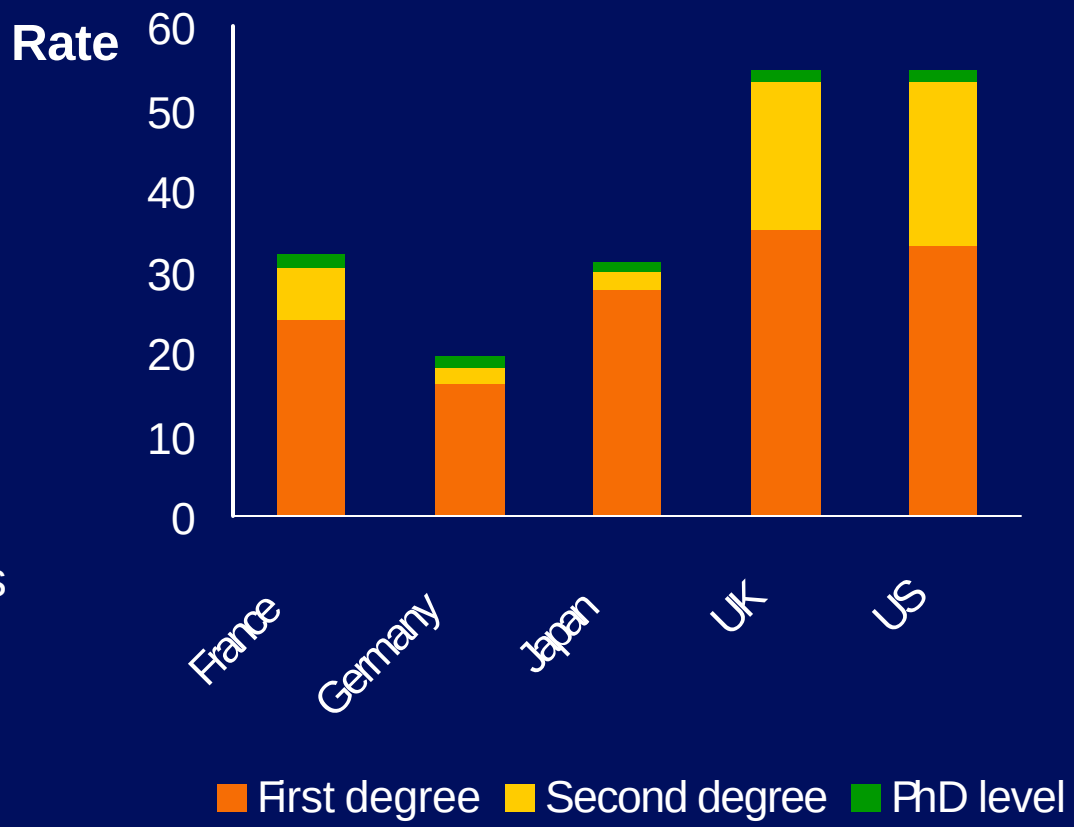
The UK research base in IT


Capability relative to US
100%
75%
50%
25%
0%
81%
78%
72%
41%
39%
25%
12%
UK
France
Germany
NDL
Sweden
Italy
Spain
Chemical & Biological Defence
Guidance Navigation & Vehicle Control
Marine
Nuclear Power
Aeronautical Technology
Information Systems
Armaments and Energetic Materials
Materials
Sensors & Lasers
Ground Systems
Information Warfare
Signature Control
Electronics
Manufacturing
Space Systems
Directed & Kinetic Energy
Weapon Effects & Countermeasures

The UK has a strong graduate workforce

The UK, like the US, has a high graduation rate in tertiary education, and a high proportion of second degrees and PhD's.

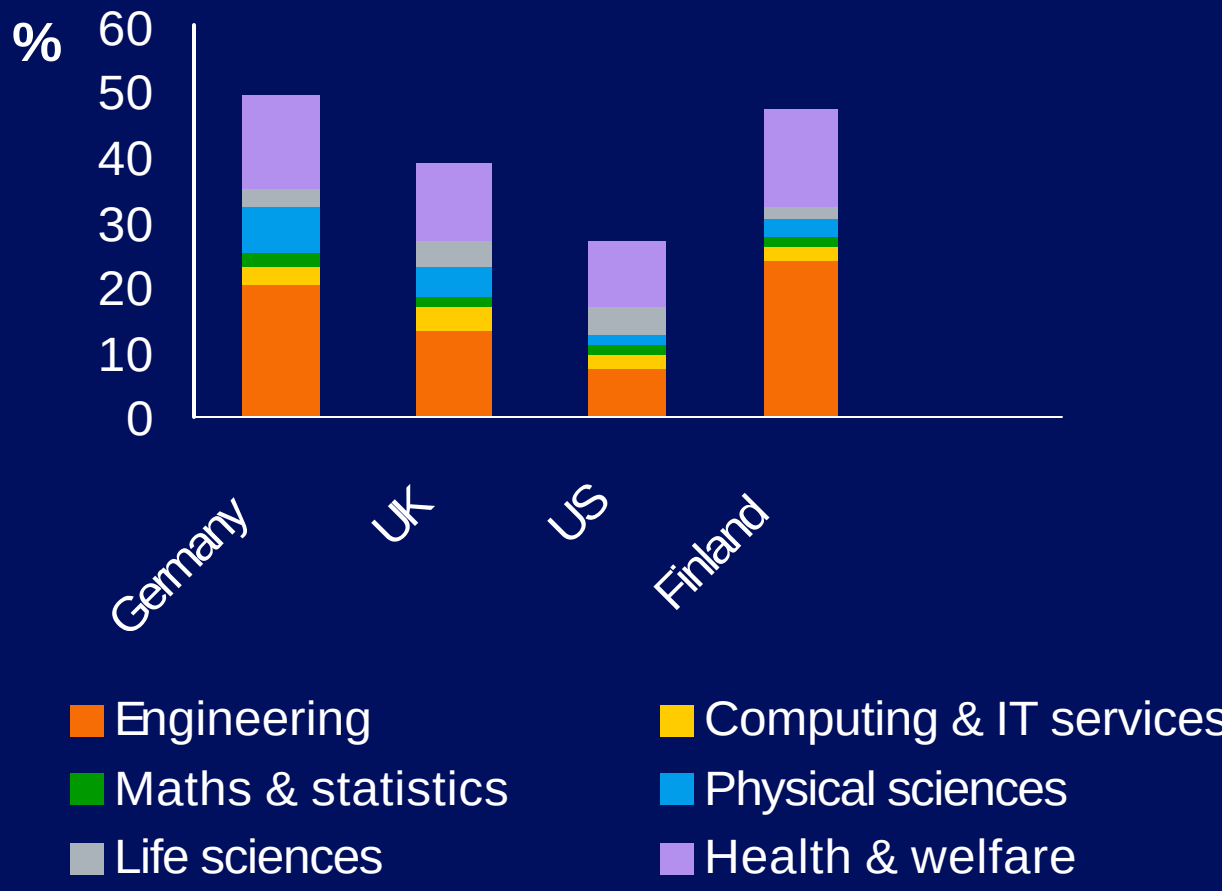
Graduation rate = graduates as percentage of those of normal age of graduation.



Source OECD 2000

Graduates in science and technology

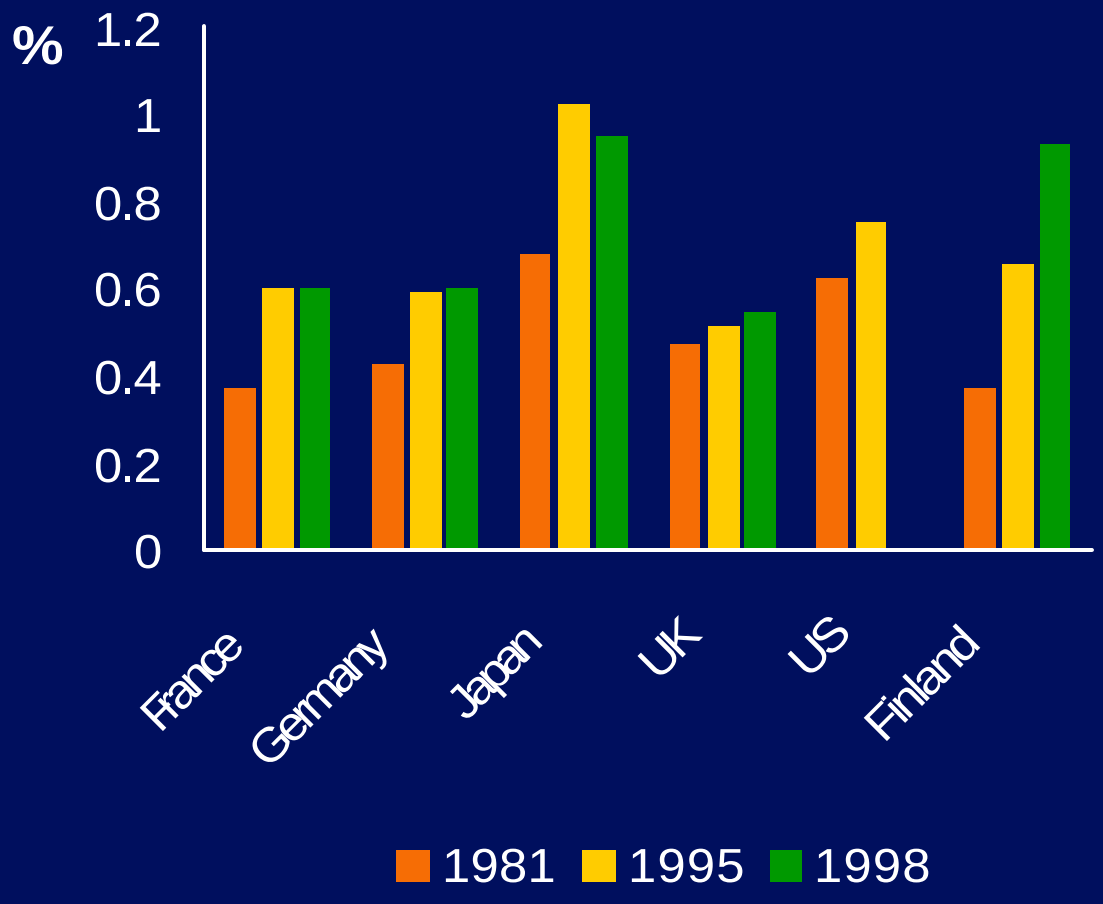
The UK has a comparatively large proportion of its graduates in computing, software and IT services.



Source OECD 2000

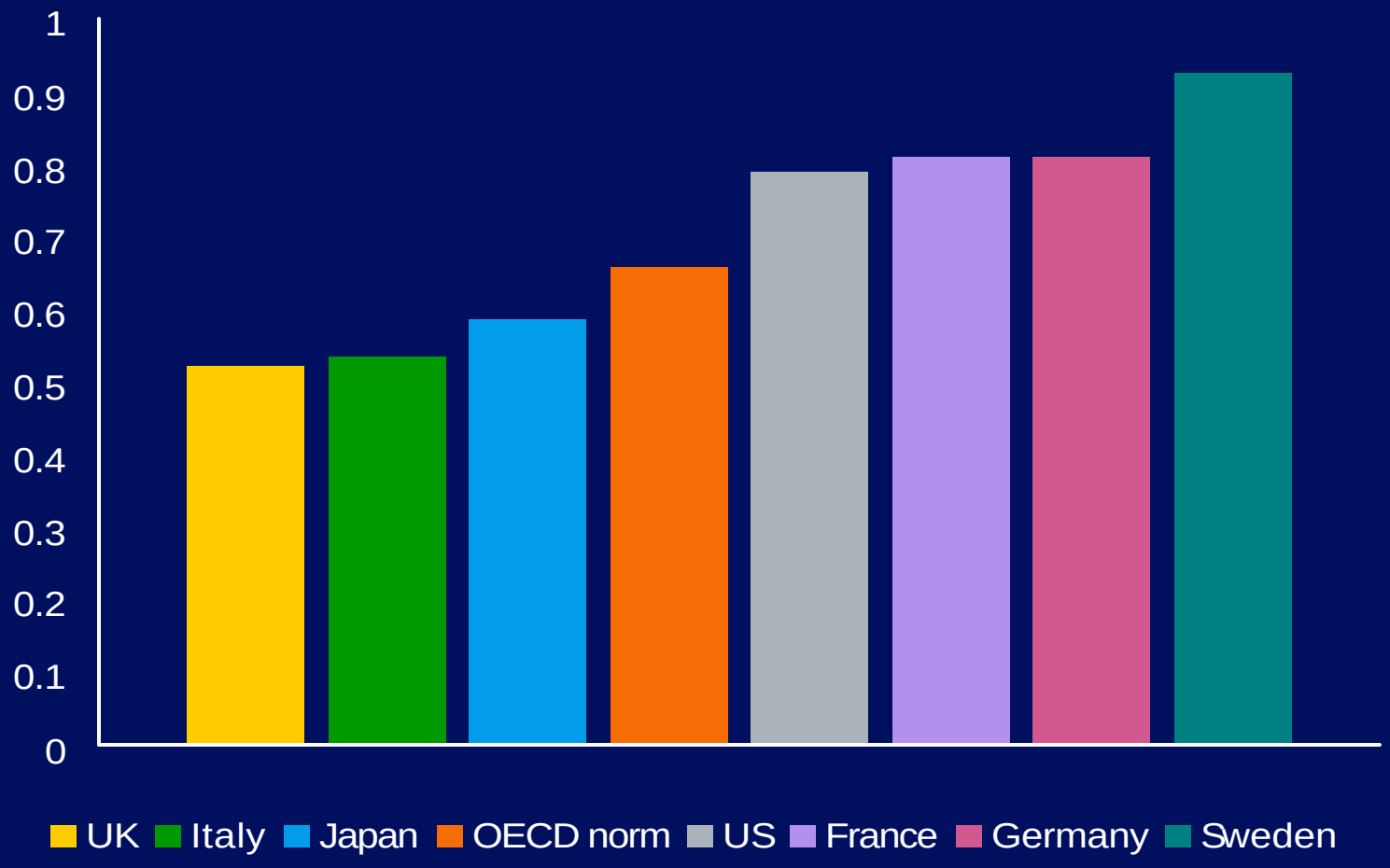
Percentage of researchers in labour force

The UK used to have proportionately more researchers than other major technological nations, but has now slipped to the bottom.



Source: OECD 2001

Govt. expenditure on R&D as % of GDP



How UK R&D compares internationally

	% of total world R&D	% of total UK R&D	R&D Intensity in 2001 UK	UK/World
IT hardware	27.3	7.5	6.2	0.8
Telecommunications	2.2	2.9	1.0	0.6
Electronics	9.6	4.3	3.0	0.5
Software and IT services	4.3	4.8	4.2	0.3
Aerospace	3.9	10.0	7.7	1.7
Automotive	17.7	5.5	4.2	1.0
Engineering	2.8	2.8	1.3	0.5
Total	67.8	37.8		

R&D intensity is the ratio of R&D expenditure to sales revenue

How UK R&D compares internationally

	% of total world R&D	% of total UK R&D	R&D Intensity in 2001 UK	UK/World
IT hardware	27.3	7.5	6.2	0.8
Telecommunications	2.2	2.9	1.0	0.6
Electronics	9.6	4.3	3.0	0.5
Software and IT services	4.3	4.8	4.2	0.3
Aerospace	3.9	10.0	7.7	1.7
Automotive	17.7	5.5	4.2	1.0
Engineering	2.8	2.8	1.3	0.5
Total	67.8	37.8		

R&D intensity is the ratio of R&D expenditure to sales revenue

How UK R&D compares internationally

	% of total world R&D	% of total UK R&D	R&D Intensity UK	in 2001 UK/World
IT hardware	27.3	7.5	6.2	0.8
Telecommunications	2.2	2.9	1.0	0.6
Electronics	9.6	4.3	3.0	0.5
Software and IT services	4.3	4.8	4.2	0.3
Aerospace	3.9	10.0	7.7	1.7
Automotive	17.7	5.5	4.2	1.0
Engineering	2.8	2.8	1.3	0.5
Total	67.8	37.8		

R&D intensity is the ratio of R&D expenditure to sales revenue

How UK R&D compares internationally

	% of total world R&D	% of total UK R&D	R&D Intensity in 2001 UK	UK/World
IT hardware	27.3	7.5	6.2	0.8
Telecommunications	2.2	2.9	1.0	0.6
Electronics	9.6	4.3	3.0	0.5
Software and IT services	4.3	4.8	4.2	0.3
Aerospace	3.9	10.0	7.7	1.7
Automotive	17.7	5.5	4.2	1.0
Engineering	2.8	2.8	1.3	0.5
Total	67.8	37.8		

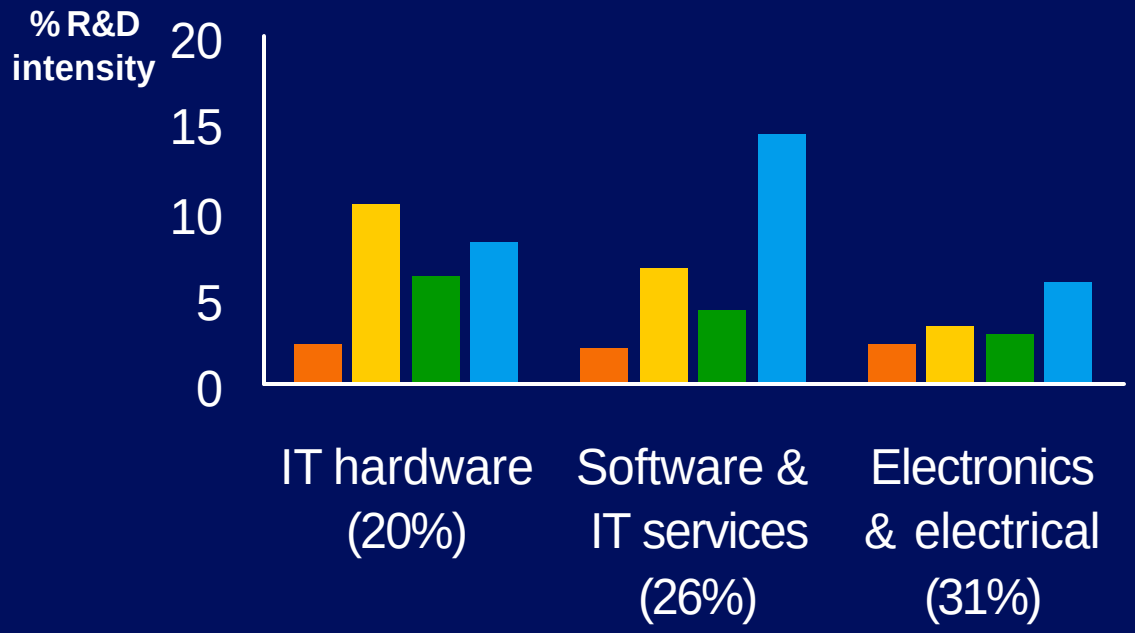
R&D intensity is the ratio of R&D expenditure to sales revenue

How UK R&D compares internationally

	% of total world R&D	% of total UK R&D	R&D Intensity UK	in 2001 UK/World
Pharmaceuticals	15.7	37.7	14.8	1.2
Chemicals	5.0	2.7	1.4	0.3
Health	2.0	1.7	7.2	1.4
Food processors	0.8	5.8	1.6	0.9
Oil and gas	1.4	4.3	0.3	0.7
Total	24.9	52.2		
Other sectors	7.3	10.0		

R&D intensity is the ratio of R&D expenditure to sales revenue

UK subsidiaries of overseas companies have a lower R&D intensity



The figure in brackets is the % of total R&D in that sector performed by the UK subsidiaries of overseas companies.

Source DTI Sept 2001

QinetiQ

Some other warning indicators

- After tax, the cost of doing R&D in IT and electronics in the UK is now becoming relatively high internationally.
  - Exchange rate
  - Adverse taxation
  - Higher UK salaries for engineers in IT.
- Globalisation is encouraging companies to move their IT R&D out of the UK.
- High R&D intensity correlates with higher sales growth and high added value per employee. Hence UK companies in software, IT and electronics are likely to decline relative to their international competitors.

Half MOD's technology research is in IT, electronics and computing

• Information & signal processing technology	27%
• Chemical and biological defence technology	20%
• Electronic and optical materials and devices	13%
• Structural and signature related materials	10%
• Computing technologies	10%
• Human sciences	9%
• Energetic materials	7%
• Oceanography and operating environment	4%

based on financial attributions by DERA staff in 1999

QinetiQ

Exploiting world science and technology

iQ NewsNet

17 July 2001

Top World Stories in Science and Technology

Contents

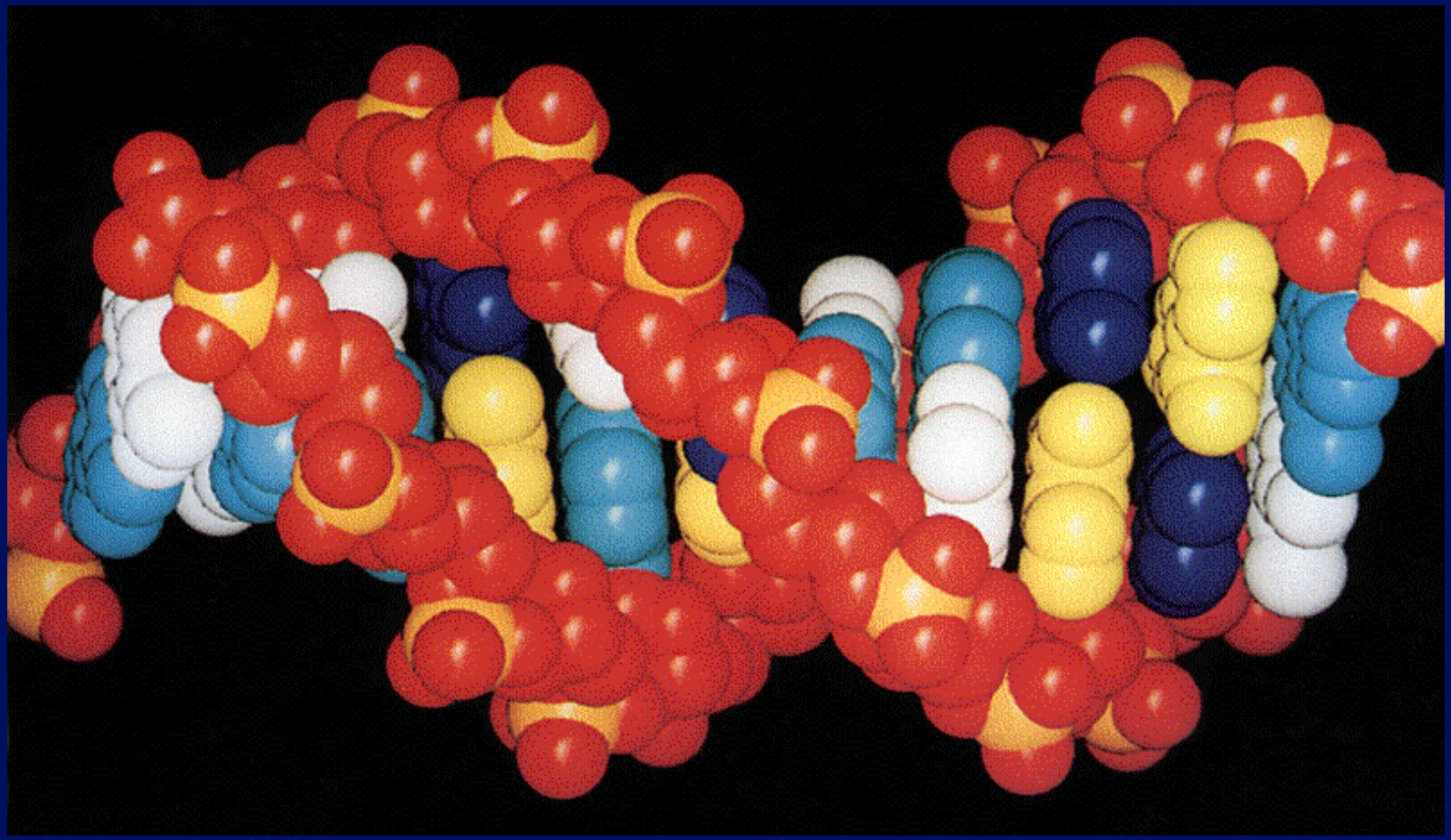
- Technology reviews
- Research and technology management
- Knowledge management
- Defence and aerospace
- Robotics and artificial intelligence
- Human science and the brain
- Simulation and virtual environments
- Man-machine interface
- Energy
- Materials and surfaces
- Data analysis and systems
- The environment
- Remote sensing and ground models
- Sensors
- Medicine and bioinformatics
- Supercomputers and distributed computing
- Information technology and security
- Future of the Internet
- Communications and navigation
- Microelectronics and spintronics
- Nanotechnology and molecular technology
- Fundamental science

Help and Guidance on this Newsletter

Technology reviews — Back to TOP

The June issue of the Economist Technology Quarterly includes articles on nanotechnology, gene sequencing, paper batteries, surround sound, extreme UV lithography, sugar-powered robots, distributed computing, commercial implications of peer-peer computing, and automatic control of cars. It also

UK is well placed in computational science, informatics & knowledge technology



QinetiQ

Section 2

IT - the past and the future

QinetiQ

The past and future of IT

- **Extended Enterprise**
- **Integrated Enterprise**
- **Group/ team**
- **Individual people**

The past and future of IT

- **Extended Enterprise**
- **Integrated Enterprise**
- **Group/ team**
- **Individual people**

Data **Information** **Knowledge**

The past and future of IT

- **Extended Enterprise**
- **Integrated Enterprise**
- **Group/ team**
- **Individual people**

Data **Information** **Knowledge** **Thought**

QinetiQ

Thought-enhancing technologies

- Decision support and mentoring tools
- New creativity, learning and training technologies
- Neuro-electronics and brain-mimetic computers
- New human-computer interfaces including implanted sensors and processing

Where we were 20 years ago

- **Extended Enterprise**
- **Integrated Enterprise**
- **Group/ team**
- **Individual people**

Personal computer

Data **Information** **Knowledge**

Thought

Where we were 5 years ago

- **Extended Enterprise**
- **Integrated Enterprise**
- **Group/ team**
- **Individual people**

Enterprise resource mgmt. & intranet

Groupware

INTERNET

Personal computer

Mobile comms and information

Data **Information** **Knowledge**

Thought

Where we are today

- **Extended Enterprise**

E-business

- **Integrated Enterprise**

Enterprise resource mgmt. & intranet

- **Group/ team**

Groupware

INTERNET

- **Individual people**

Personal computer

Mobile comms and information

Data **Information** **Knowledge**

Thought

What is emerging now?

- **Extended Enterprise**

GRID computing

E-business

Knowledge store

- **Integrated Enterprise**

Enterprise resource mgmt. & intranet

- **Group/ team**

Groupware

INTERNET

- **Individual people**

Personal computer

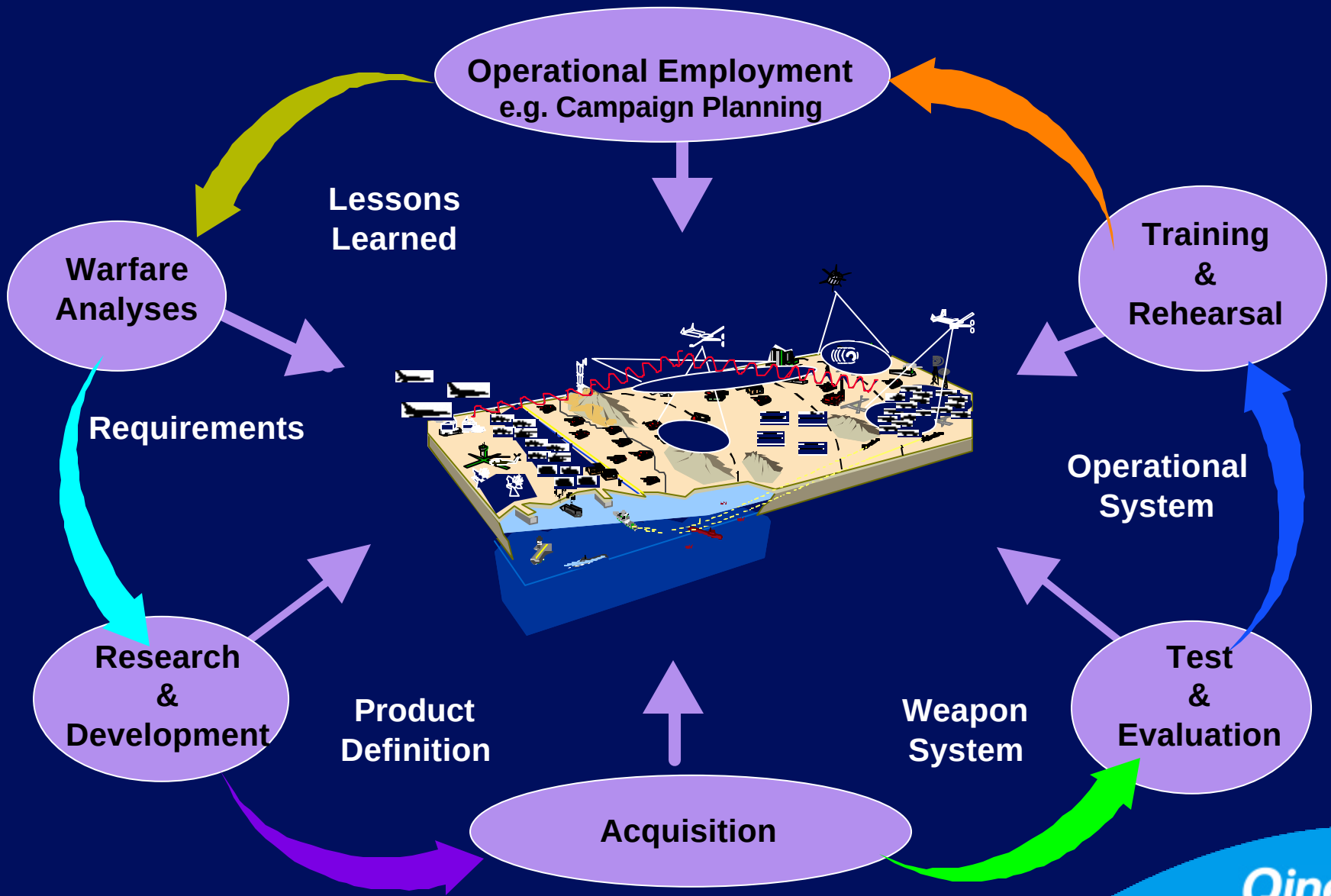
Mobile comms and information

Data **Information** **Knowledge**

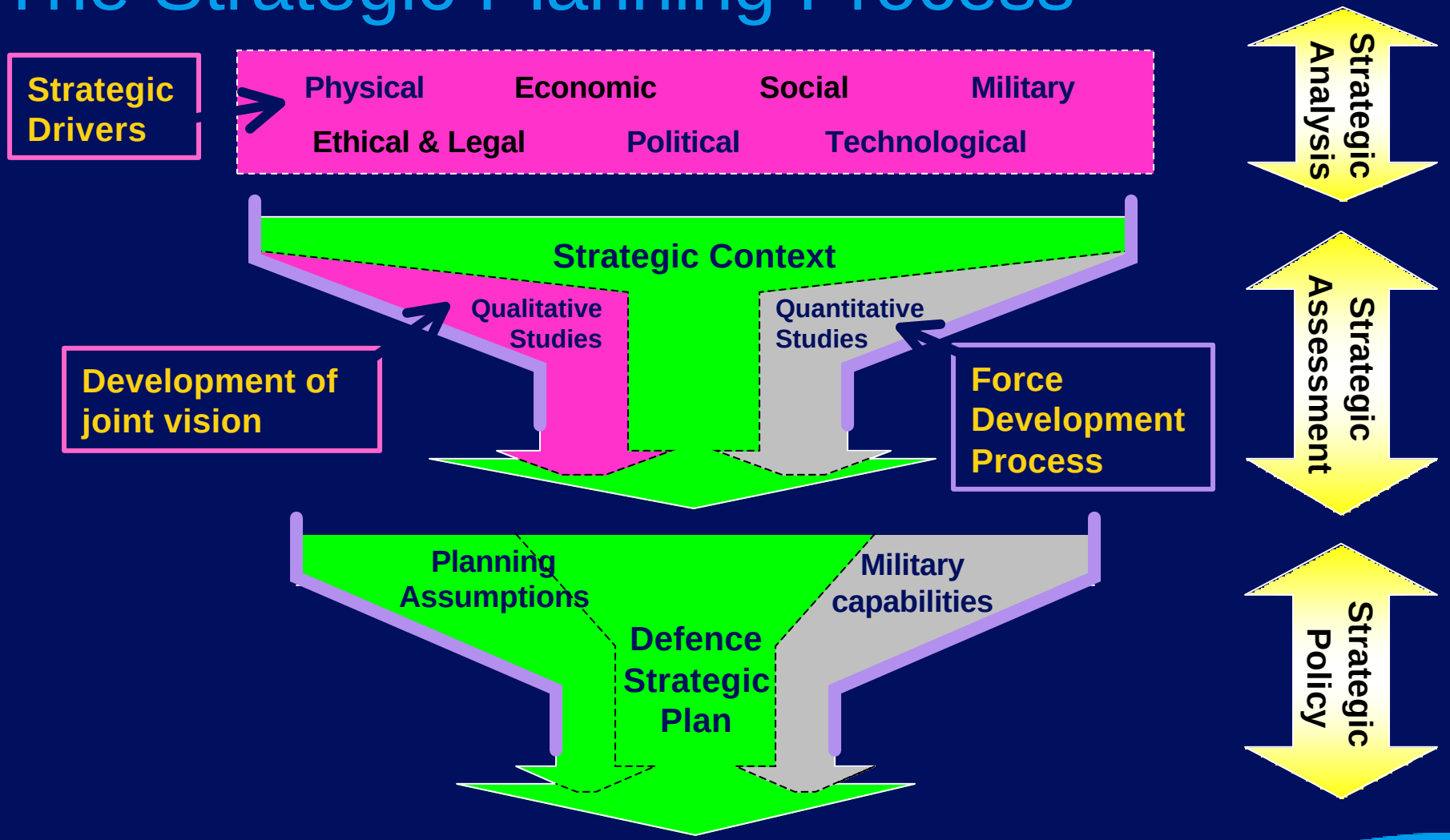
Thought

Global Data Enterprises

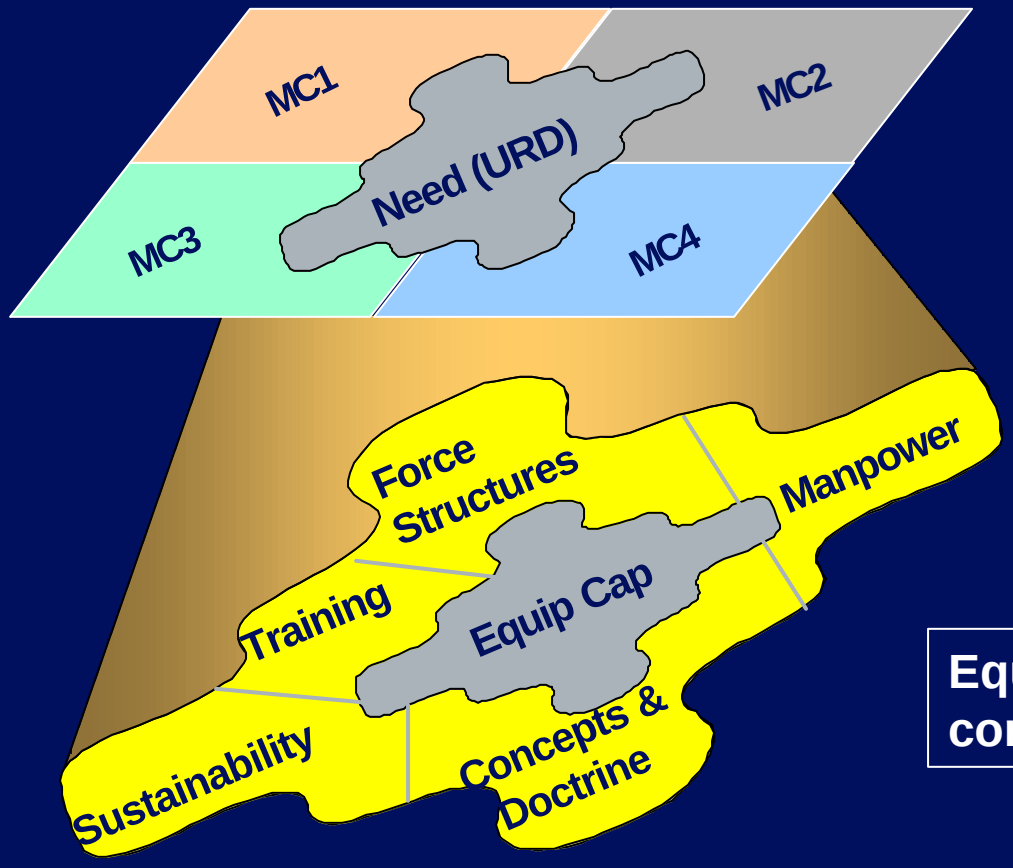
- Petabyte data analysis (e.g. large hadron collider, genomics, environment).
- Computational science, engineering and medicine using distributed modelling, simulation and supercomputing.
- Multidisciplinary design optimisation, multicompany distributed design and evaluation; whole life databases.
- International databases (e.g. protein/gene database, personal medical databases, international system databases)
- Importance of data maintenance and rescue, and of emerging standards, common representation, language, comprehension.


Operational Employment
e.g. Campaign Planning
Lessons Learned
Warfare Analyses
Training & Rehearsal
Requirements
Operational System
Research & Development
Product Definition
Weapon System
Test & Evaluation
Acquisition

The Strategic Planning Process



Capability based acquisition

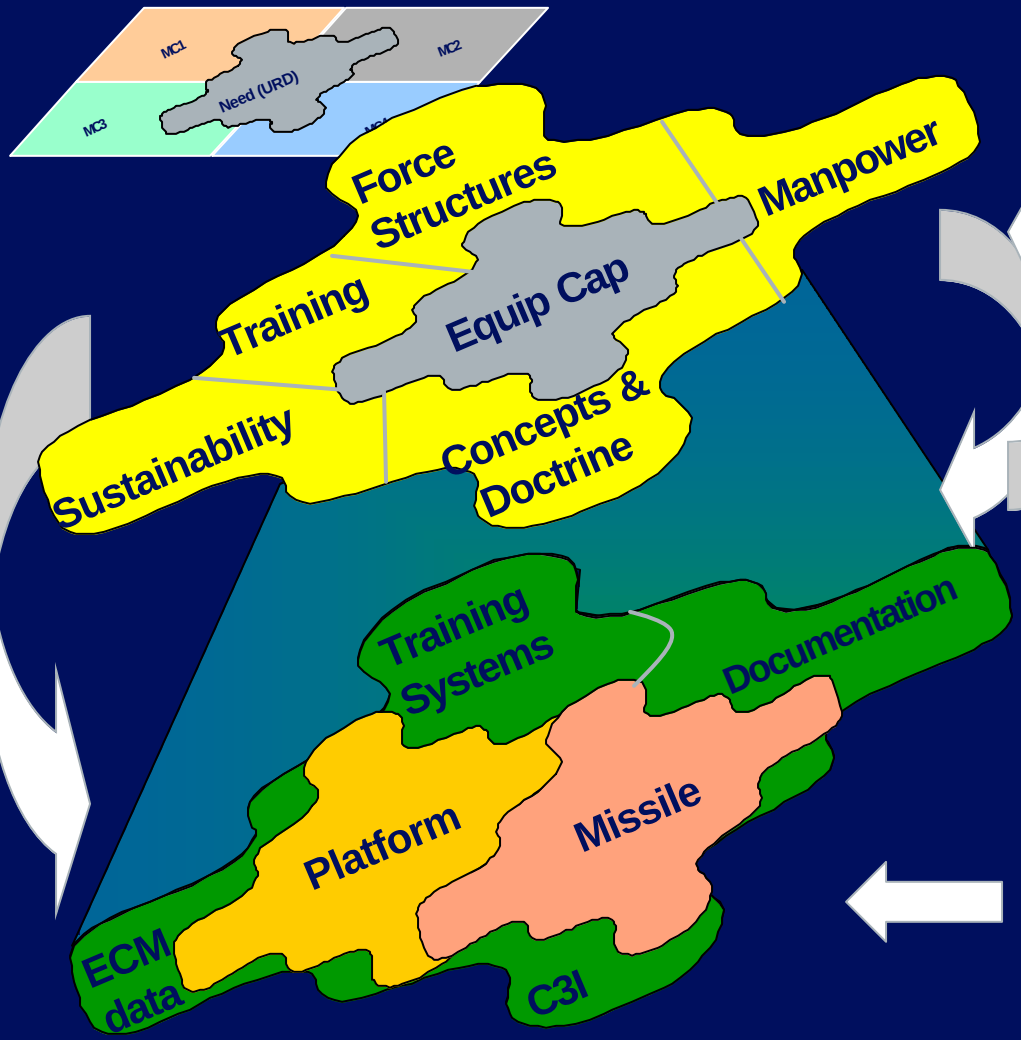


Military capability need & context for acquisition

Capability constraints e.g.:
- **Interoperability**
- **Scenarios**
- **Environments**

Equipment capability need & context for equipment acquisition

Capability based acquisition



Equipment capability need & context for equipment acquisition

Equipment constraints:
- Interface agreements,
- Operating intent & usage
- Support policy,
- Target Audience Descriptions
- CONOPS
- Tactics, etc.

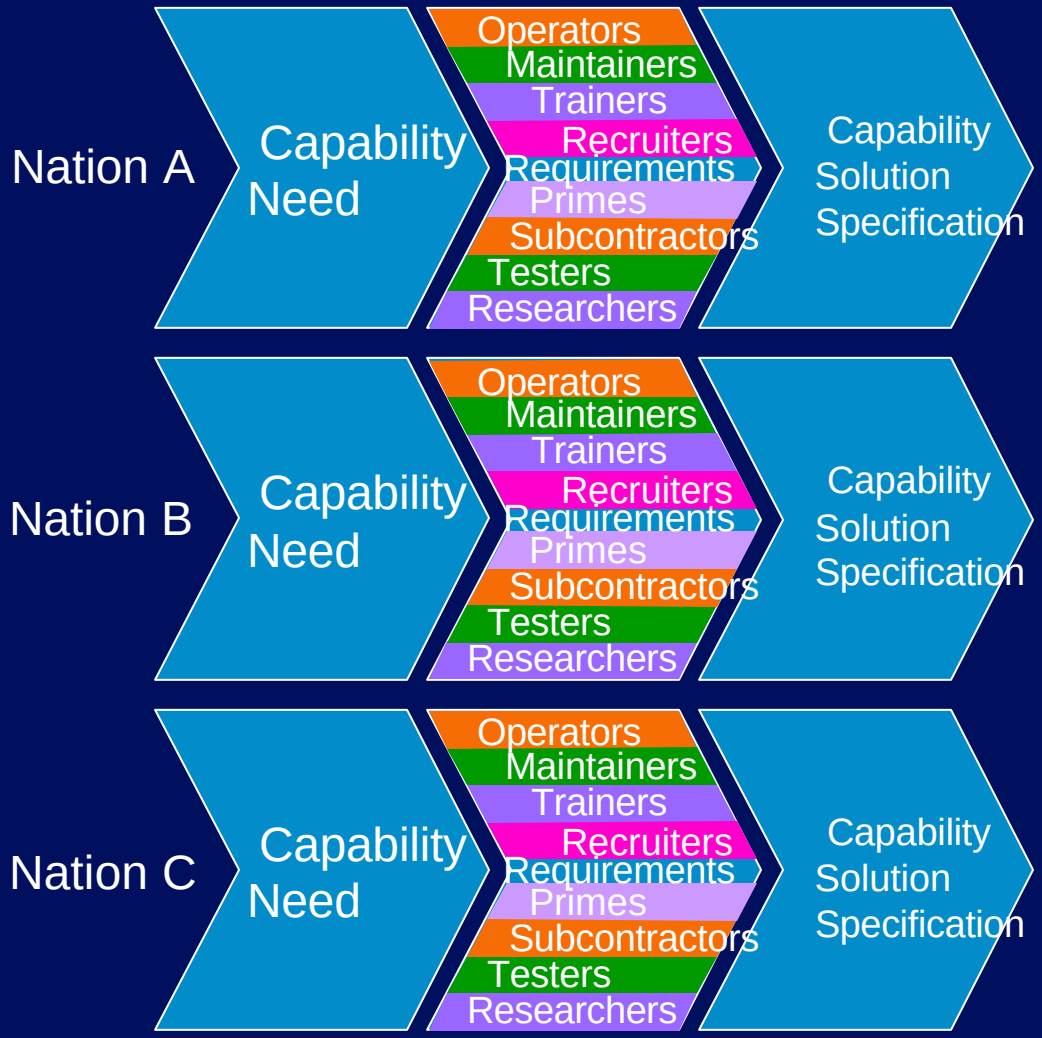
System Requirements SRD

System constraints eg:
- Interoperability
- policies
- standards

Motor Industry

Concurrent engineering has been very successful in the car industry, for example. However, uncertainty, complexity, lack of continuity, and shortness of production runs make defence systems much more challenging for concurrent engineering.

Contracting for capability could be like this

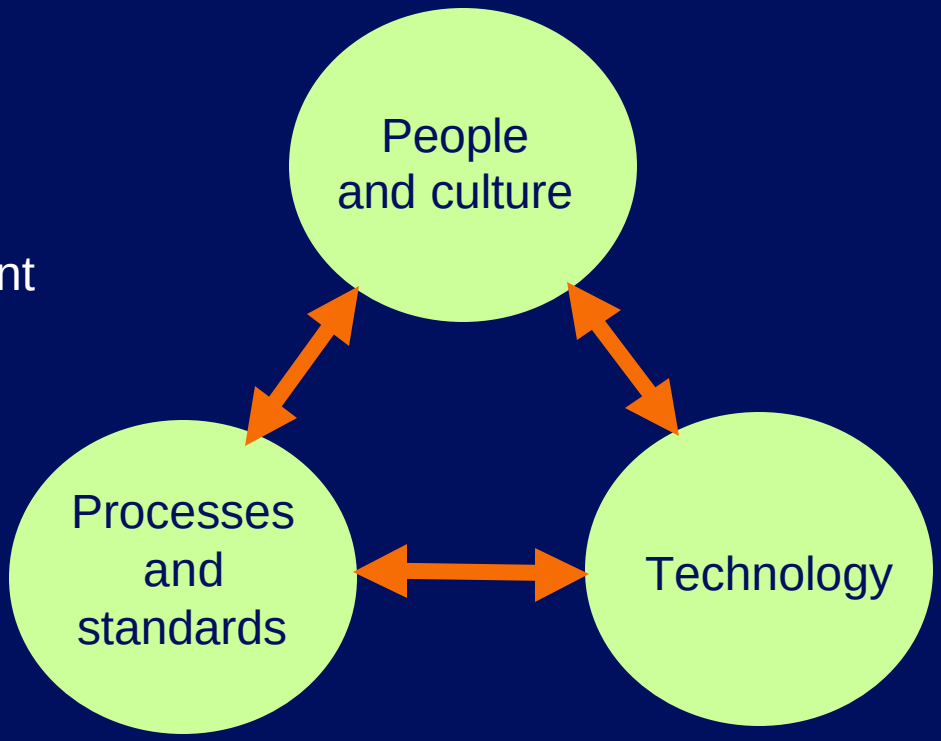


Multi-national Service Provider

QinetiQ

Information technology is not enough

All three are equally important



Section 3

Future C4ISTAR challenges

New limitations

ARMY
BE THE BEST

ROYAL NAVY
THE TEAM WORKS

ROYAL AIR FORCE
RISE ABOVE THE REST

QinetiQ

Usability is crucial

Avoid complexity and overload.
System must adapt to users.
We need more research on humans and teams in the C4ISTAR system.

New capabilities and old ones

Decisions will be complex

Support must be personal, immediate and sophisticated.

New tools of war

BBC NEWS

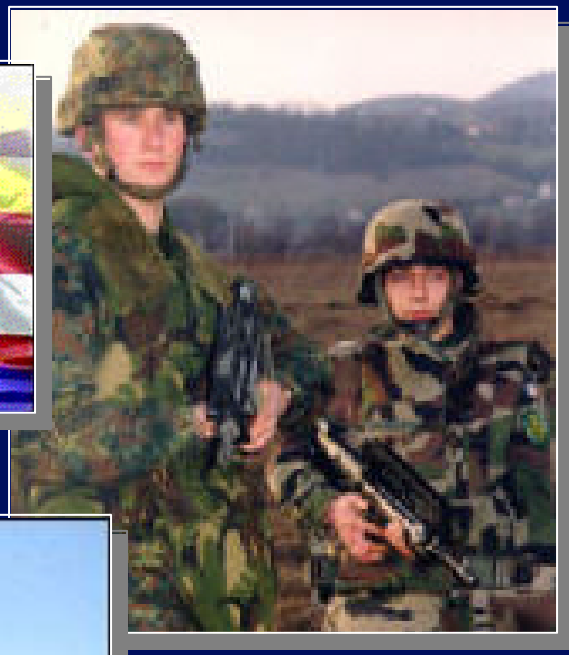
CNN.com

QinetiQ

The political battle is fought on the media.

The psychological and media aspects of C4ISTAR will be all important.

New coalitions



Interoperability is cultural as well as technical

Need to learn through training and simulation how to work together successfully.

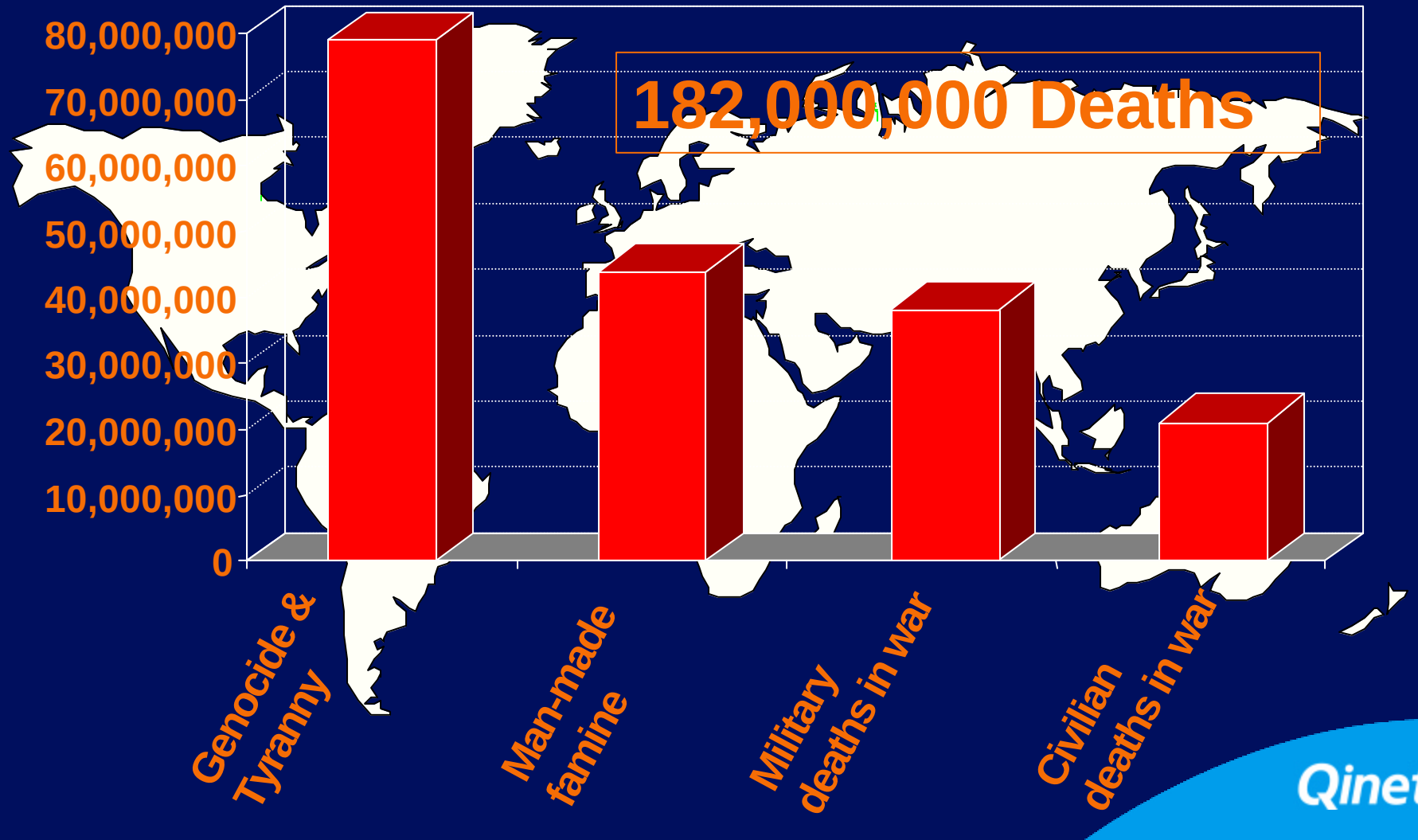
New zones of war

The world is increasingly urban and networked

Infrastructure and network vulnerabilities.

C4ISTAR for asymmetric warfare.

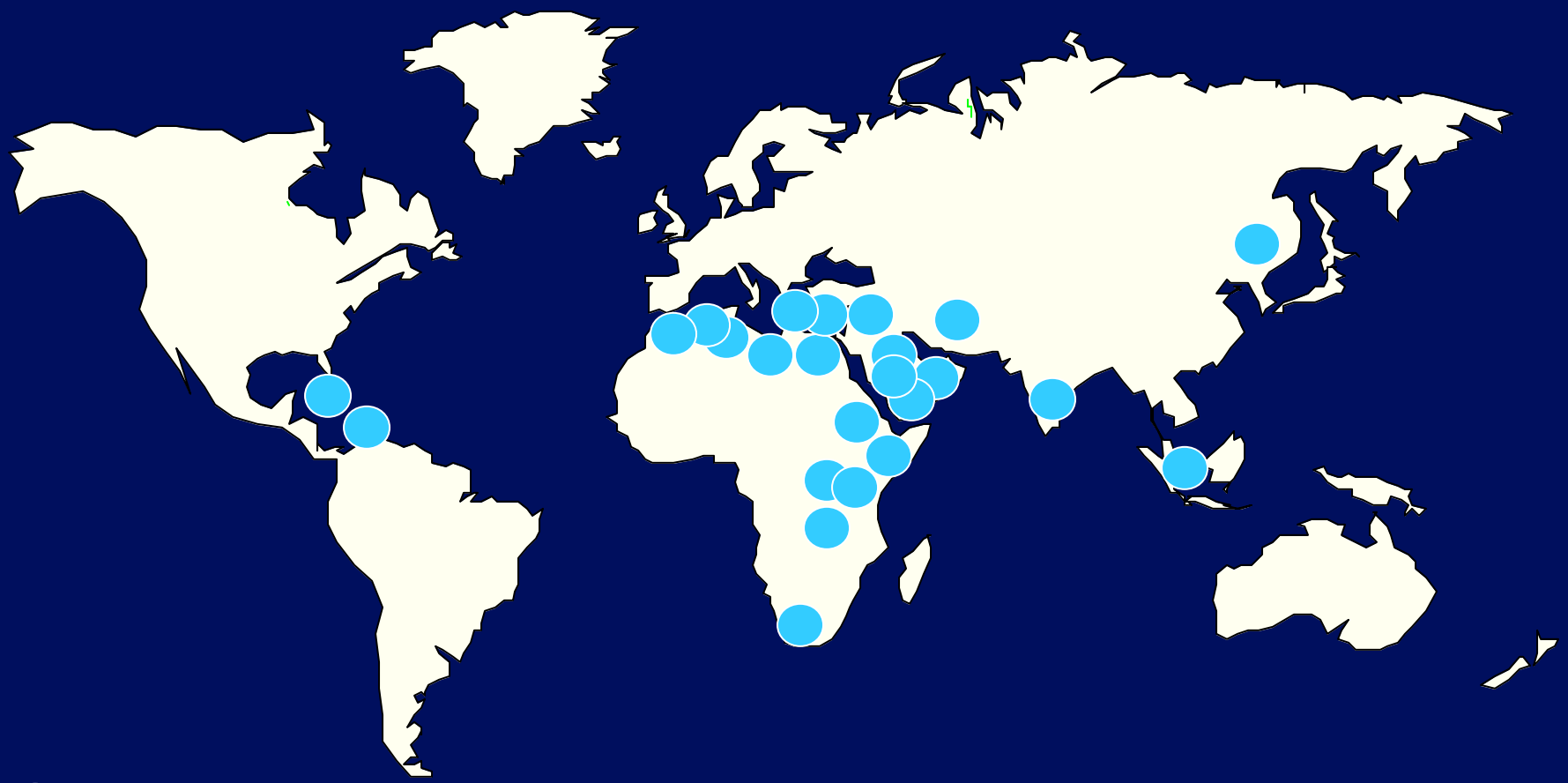
The real killers in the 20th century



Deaths this century could be even worse.

Crisis intelligence, anticipation, recognition and management.

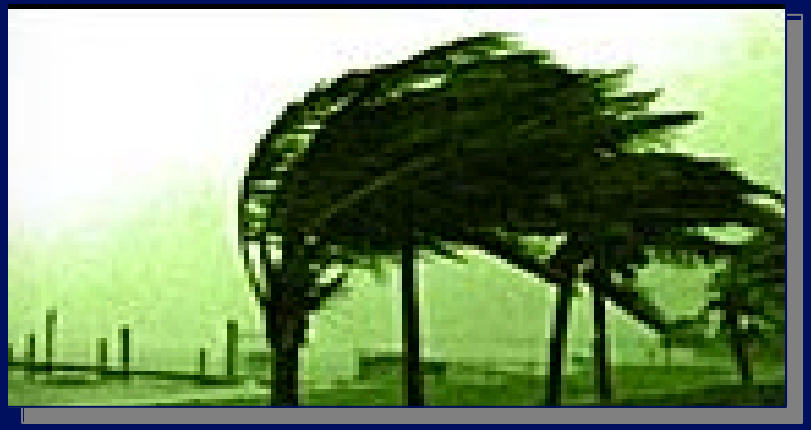
New sources of tension: Water shortage?



Water Scarcity (430 million in 1999; forecast 800 million in 2025)

QinetiQ

New sources of tension: Climate change?



New sources of tension: Space?

Expect the unexpected

Predicting the future is easy. The hard part is getting it right.

Section 4

Summary

Summary - 1

- The UK research base in IT is a mixed picture
  - strong workforce but weak R&D intensity and an indigenous industry that may be declining
  - strong MOD research but major technology gap with US
  - strength in emerging areas (informatics, knowledge technologies, computational methods).

Summary - 2

- Technology is moving towards global data enterprises and knowledge stores
  - GRID and global e-Science, petabyte data handling, distributed simulation, modelling and supercomputing as a utility.
  - Scope for very complex system engineering and for handling the complexity of capability based acquisition.
- Technology will emerge that supports human thinking much more directly (knowledge environments, advanced visualisation, telepresence, thought enhancement…).

Summary - 3

- MOD faces new challenges that make greater demands on C4ISTAR.
- Early choices have a big effect:
  - systems are never as flexible as one hopes at the outset
  - effective and imaginative strategic planning is essential.
- Research and demonstration are important in order to explore and understand the options and to have them available when needed.
- It is hugely important to be able draw on world technology and to be able to incorporate it flexibly.

Information Technology and the UK Research Base

Dr Adrian Mears
Technical Director, QinetiQ
amears@qinetiq.com

QinetiQ